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II.—ON THE LOCALITY TO WHICH THE TREATISE OF PALLADIUS *DE AGRICULTURA* MUST BE ASSIGNED.

The difficulty which exists with regard to the question with which we have headed this paper will be better understood by a reference to the article of Weiss in Michaud's Biographie Universelle, in which it is stated that Palladius (Rutilius Taurus Aemilianus), one of the most ancient writers on agriculture whose works have come down to us, is, according to Barth and Dom Rivet, the same as Palladius, the son of Exsuperantius, prefect among the Gauls.[1] The majority of critics have adopted this conjecture, which is, however, founded merely upon an identity of name. On the other side, those who suppose Palladius to have been born in Italy, and that he flourished towards the middle of the second century, can bring no solid proof to support their opinion. So that the origin of this writer is uncertain. If we may believe Dom Rivet, he was born at Poitiers at the commencement of the 5th century,[2] and after training in eloquence according to the Gallic schools, he went to Rome to study jurisprudence. After the death of his father, who was killed in 524 (an evident error for 424) in a riot, it became a matter of indifference to Palladius whether he lived in Gaul or Italy, and it is believed that he settled himself in the neighborhood of Naples. He informs us himself that he possessed landed property in the suburbs of that city and in Sardinia, and that he himself superintended the cultivation of his estates.

Thus far Weiss in reference to this interesting writer, whose works have been but rarely edited. It will be observed that Weiss holds the reference of Palladius to the 5th century and to the locality of Gaul as a conjecture founded upon a similarity of name.

Schneider, who edited the work of Palladius in his Scriptores Rei Rustici, Lipsiae, 1795, maintains, with Gesner, against the opinion of Mylaeus, that Palladius is not a contemporary of Pliny and Quintilian; and against Ludovicus Vives, that he is not to be placed in the reign of Adrian; but he does not believe Palladius to be a native of Gaul. "Gallicae patriae *nullum plane vestigium* in opere suo signavit Palladius, nisi forte huc trahere velis ligni Gallici asseres (I 13, 1), vel messorii vehiculi descriptionem quo pars Galliarum planior utebatur" (VII 2).[1] Now Schneider's first illustration is a peculiarly unhappy one, for the passage, quoted more at length, advises that in building your country house you should employ materials which lie ready to hand, ex ea materia quae facilius invenietur, and therefore the writer recommends planks of French pine or cypress: "asseres ligni Gallici vel cupressi directos et aequales constituemus in eo loco, ubi camera facienda est." Moreover, that the writer is not an Italian is evident from the first words of the second book: "Januario mense locis temperatis ablaqueandae sunt vites, *quod Itali excodicare appellant*, id est circa vitis codicem dolabra terram diligenter aperire," etc. But we are able to approach this question in another direction than that of linguistic criticism, for Palladius has given us at the end of each month a table of the lengths of the shadows in the sun-dial for the various hours of the day and from month to month.

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[1] See article 'Exsuperantius' in Michaud, and Note 1.

[2] See Rutilius, Itinerary, I 208, and Note 2.

In the Aldine edition of Palladius, printed at Venice in 1472, a small tract is appended by Aldus to explain the system employed by Palladius for the division of the hours, and also showing how to adjust the gnomon empirically by means of the given length of shadow on a particular day. This tract is reprinted in Schneider, as doubtless by other writers. There is no doubt that Aldus judges rightly in maintaining the hours of the day according to Palladius are always twelve, and these make up the interval between sunrise and sunset. Thus in the month of June the length of the shadow is given in feet as follows:

Horae	i &	xi	22
	ii	x	12
	iii	ix	8
	iv	iix	5
	v	vii	3
	vi		2

But whether this day is composed of twelve *equal* civil hours is not mentioned; nor, as Sir G. C. Lewis remarked in his treatise on the Astronomy of the Ancients, is it stated what is the length of the pointer which casts the shadow. Moreover, we are not informed on what particular day (whether at the beginning, middle, or end of any month) the measurement for that month is made; and we shall see by reference to the data of Palladius that his measurements certainly never run nearer than to the nearest integral number of feet; nor are we told what kind of a sun-dial is employed. We will first transcribe Palladius' 12 tables into one, observing that it is only necessary to note the shadows for half the day, since the lengths repeat in inverse order; and for half a year, since he makes the months also coincide two and two, January with December, February with November, and so on.

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[1] See Note 3 for this earliest form of reaping-machine.

TABLE I.

Horae	*January*	*February*	*March*	*April*	*May*	*June*
i & xi	xxix pedes	xxvii	xxv	xxiii	xxiii	xxii
ii x	xix	xvii	xv	xiiii	xiii	xii
iii ix	xv	xiii	xi	x	ix	viii
iv iix	xii	x	viii	vii	vi	v
v vii	x	viii	vi	v	iiii	iii
vi	ix	vii	v	iiii	iii	ii

Now, to begin with, with regard to the apparatus by which the shadow is cast, we may say that if it is a sun-dial it is not a vertical south dial, for the shadow is cast whenever the sun is above the horizon. We infer, therefore, either that it is a horizontal dial, or that Palladius is even more elementary and is in fact measuring what is practically the shadow of a vertical stick.

On the hypothesis of a horizontal dial the shadow at midday is given by

$$\frac{\cos \delta}{\cos \overline{\phi - \delta}} \times \text{length of style},$$

where δ is the sun's northerly declination and ϕ the latitude. Thus the ratio of shadows at periods of the year six months apart is $\cos \overline{\phi - \delta} : \cos \overline{\phi + \delta}$. Taking figures from our table we have

$$\frac{1 + \tan \phi . \tan \delta}{1 - \tan \phi . \tan \delta} = \frac{9}{2}$$

therefore

$$\tan \phi = \frac{7}{11} \cot \delta$$

δ being the sun's declination somewhere between December 1 and January 31. Now, if we give δ its greatest value we have

$$\delta = 23° \, 20' \quad \text{and} \quad \phi = 55° \, 52'.$$

If we had supposed observations made at the beginning of December, or when $\delta = 22°$, we have

$$\phi = 57° \, 36'.$$

It is evident that these latitudes are a great deal too far north to be admissible. Moreover, if we take a particular latitude such as Rome (42° N) and calculate the shadows for the end of the first week of each month, we shall find it difficult to harmonize our results with the given data; thus a four-foot style would give midday shadows

8.4 7.1 5.6 4.8 4.1 3.9

and the divergence is as great when we take for instance latitude 47°, that is, if we go five degrees north of Rome, where we get

9.3 8.2 6.4 6.1 4.4 4

with a style four feet in length. And if we imagine the author to have carried a sun-dial adjusted at Rome five degrees north, the results when corrected are even more divergent. A reference to Table III shows how impossible is the hypothesis of a horizontal dial. So that we can not even assume that our author has imitated the foolish parade of the Romans when they brought a valuable sun-dial from Syracuse and fixed it up without correction for change of latitude, in the Comitium.[1]

It seems that we must abandon this hypothesis and seek a simpler one; and here we are helped by the remembrance that the earliest form of the sun-dial is not one with an elevated gnomon starting from the centre of the dial, but is composed of two strips of metal or wood, one horizontal and in the north and south line of the dial, and the other at right angles to it and perpendicular to the plane of the dial and of a proper height to adjust the instrument to the latitude of the place.

It is, therefore, in the highest degree likely that Palladius has employed a dial of this kind, and he may even have measured his shadows from the foot of the upright pointer and not from the middle of the plate. Our figures then give us

from June $x \, . \tan \overline{\phi - \omega} = 2$
and December $x \, . \tan \overline{\phi + \omega} = 9$

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[1] Bunsen. Hippolytus I 430.

where x is the length of the vertical style, ϕ is the latitude, and ω the obliquity of the ecliptic. This leads us to the conclusion that

$$x^2 - 7x \cot 2\omega + 18 = 0\,,$$

which is certainly an impossible equation, if ω have the value ordinarily ascribed to it. Either, therefore, the measurements are incorrect, or they are not made at the solstices, or else we shall be forced to abandon the hypothesis of a vertical style as well as the previous one. We observe, however, that at the corresponding times of the winter and summer the ratio of the shadows is $\tan(\phi + \delta) : \tan(\phi - \delta)$, a proportion which for various values of ϕ ranges from ∞ to ∞ as ϕ changes from δ to $\frac{\pi}{2} - \delta$, and has therefore a minimum value between those limits, viz. when $\phi = \frac{\pi}{4}$, in this case the ratio is $\tan^2\left(\frac{\pi}{4} + \delta\right)$; which shows us that at the solstices the winter shadow at midday is 6¼ times the summer one in latitude 45°, and a greater proportion in every other latitude; and the winter shadow when the sun's declination is 20° is 4½ times the summer shadow in latitude 45°, and greater in every other latitude. Now 4½ is the proportion of winter and summer shadows, according to our author.

We cannot then be very far from latitude 45°; and, assuming this latitude for the moment, we have

$$x \,.\, \tan(\phi - \omega) = 2$$
$$x \,.\, \tan(\phi + \omega) = 9$$

equations which we know to be somewhat inconsistent.

The first gives us $x = 4.8$
the second $x = 5.4$

and we may therefore infer that the style by which the shadow was cast was 5 feet in length. Assuming therefore a vertical staff 5 feet in length, we construct Table II, which gives us the actual shadows for four principal latitudes for every week of the first six months of the year. A comparison of our table with the data of Palladius confirms our supposition that we are not far from latitude 45°. Athens is evidently a great deal too far south.

Now, before we go further, we must remark that of all the results given by Palladius the most correct will probably be those given for June, because the weather is probably clear, and, the sun scarcely varying a degree in declination during the whole month, we may therefore expect the shadows to be accurately measured. On the other hand winter measurements are least trustworthy, for the opposite reasons. Moreover, of measurements made on any given day, the first is likely to be very sensibly less than the theoretical value, because the sun is raised by refraction, especially when on the horizon, and consequently casts a shorter shadow than it ought. Another perceptible error in the opposite direction may be expected if the hours are marked by a clepsydra adjusted to the month or day; the water runs out too fast at first, and the early hours are a little short perhaps;[1] this makes the shadows of Palladius somewhat longer than they ought to be, in the beginning of the day; but I do not suppose that this error will compensate the one introduced by refraction. A difference of a degree in altitude makes a difference of 3 feet nearly in the shadow, when the altitude is 10°.

So far our table has only served to assure us that we were right in putting five feet for the length of the style, and that the latitude is not far from 45°; but we are scarcely able to decide with certainty between 42°, 45°, and 47°. We therefore proceed to calculate the shadows for every hour of the civil day, at the time of the equinox, for the latitudes in question. The results are given in Table IV; and bearing in mind the cautions given a little while ago with regard to the longest shadows, the comparison *is decisive in favor of latitude* 45°; but latitude 47° is better than that of 42°; and, as we have pointed out, these are the results upon which we can best rely, being made at midsummer.

Lastly, we have calculated, from the assumption that the sun is in the equator, the lengths of the shadows for the whole of the civil day at the equinox. It is not perfectly easy to decide at what date the sun, according to Palladius, passes the equinox; assuming it to be somewhere in March or April, we see by reference to Table V that the judgment is against the latitude of Rome, and in favor of one even more northerly than 45°.

Upon the whole we conclude that the measurements given by Palladius refer to a latitude at least as high as 45°; *i. e.* to a country very much further north than Sardinia, Naples, or Rome; and in fact it can only be Gaul, perhaps as far north as Aremorica, the province to which Exsuperantius, who must now be regarded as the father of our Palladius, is referred by Rutilius in his Itinerary. There are especial reasons for a reference to latitude 45°. We may show that a table of shadows must actually have been in existence for that latitude.

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[1] "The supposed determination of an instant by means of clepsydras is likewise futile; for the contents of the jar will not flow out in the same time [? at the same rate] when it is full as when it is half empty."—Hippolytus, Philosophumena IV 5.

A reference to Vitruvius, de Architectura XI, c. iv, gives us the following information on the subject of sun-dials: "Ea autem sunt divina mente comparata habentque admirationem magnam considerantibus, quod umbra gnomonis aequinoctialis alia magnitudine est Athenis, alia Alexandriae, alia Romae, non eadem Placentiae ceterisque orbis terrarum locis. Itaque longe aliter distant descriptiones horologiorum locorum mutationibus." Critics have been puzzled to explain the force of the reference to Placentia; the interpretation is that the 45th parallel of latitude was actually over the city, or as nearly as could be determined by persons of limited ability and apparatus. It was especially easy to set up a sun-dial in this latitude, the gnomon being immediately constructed by means of a right angled isosceles triangle.

We may, I think, conclude that the measurements of Palladius are the shadows of a vertical rod 5 feet in length, in latitude 45°, or a little to the north of it; that the treatise is therefore properly ascribed to Gaul, Palladius fairly identified as the son of Exsuperantius to whom St. Jerome wrote one of his epistles, and that it is not true, as Weiss and other critics have affirmed, that the reference to Gaul is founded merely upon a similarity of name.

It is a delicate matter to establish very positive conclusions upon very incomplete data, but I think we have established our conclusion. As Aldus observes, a complete series of observations *by experiment* would require a large book and a long life. "Observandi forent dies sereni multorum annorum donec omnes describerentur. Quod quia laboriosum est, et longi taedii plenum, nec Palladius fecit, nec alius quisquam, nec forte erit unquam qui faciat. Sed de his haec satis. Tu vero, lector carissime, vale et me ama."

TABLE I.—*Table of Shadows from Palladius, De Agriculturâ.*

Horae	*January*	*February*	*March*	*April*	*May*	*June*
i et xi	xxix pedes	xxvii	xxv	xxiii	xxiii	xxii
ii et x	xix	xvii	xv	xiiii	xiii	xii
iii et ix	xv	xiii	xi	x	ix	viii
iv et iix	xii	x	viii	vii	vi	v
v et vii	x	viii	vi	v	iiii	iii
vi	ix	vii	v	iiii	iii	ii

TABLE II.—*Table showing the lengths of the actual shadows at midday for a vertical stick of length either* 1 *foot or* 5 *feet, the latitudes being noted on the margin, and the sun's declination for the day being taken to the nearest degree.*

	January				*February*				*March*			
Latitude	1	8	15	22	1	8	15	22	1	8	15	22
38° Athens 37° 58′	1.80	1.73	1.66	1.60	1.42	1.32	1.23	1.11	1.00	.93	.83	.78
	9.00	8.6	8.3	8.0	7.1	6.6	6.1	5.5	5.0	4.6	4.1	3.9
	Average		8.2				6.0				4.2	
42° Rome 41° 53′	2.14	2.05	1.96	1.73	1.66	1.53	1.42	1.27	1.17	1.07	.96	.90
	10.7	10.2	9.8	8.6	8.3	7.6	7.1	6.3	5.8	5.3	4.8	4.5
	Average		9.5				7.0				4.8	
45° Placentia	2.47	2.35	2.24	2.14	1.88	1.73	1.60	1.42	1.30	1.19	1.07	1.00
	12.3	11.7	11.2	10.7	9.4	8.6	8.0	7.1	6.5	5.9	5.3	5.0
	Average		11.0				7.9				5.4	
47° Poitiers 46° 50′	2.74	2.60	2.47	2.35	2.05	1.88	1.73	1.53	1.40	1.27	1.15	1.07
	13.7	13.0	12.3	11.9	10.1	9.4	8.6	7.5	7.0	6.3	5.6	5.3
	Average		12.2				8.5				5.7	

	April				*May*				*June*				
Latitude	1	8	15	22	1	8	15	22	1	8	15	22	30
38° Athens 37° 58′	.66	.60	.53	.48	.42	.38	.34	.32	.28	..	..	..	.26
	3.3	3.0	2.6	2.4	2.1	1.9	1.7	1.6	1.4	..	..	..	1.3
	Average		2.7				1.7				1.3		
42° Rome 41° 53′	.76	.70	.62	.57	.50	.46	.42	.38	.36	..	..	..	.34
	3.8	3.5	3.1	2.8	2.5	2.3	2.1	1.9	1.8	..	..	..	1.7
	Average		3.1				2.1				1.7		
45° Placentia	.88	.78	.70	.64	.57	.53	.48	.46	.42	..	..	..	.40
	4.4	3.9	3.5	3.2	2.8	2.6	2.4	2.3	2.1	..	..	..	2.0
	Average		3.5				2.4				2.0		
47° Poitiers 46° 50′	.91	.83	.75	.70	.62	.57	.53	.50	.46	..	..	..	.44
	4.5	4.1	3.7	3.5	3.1	2.8	2.6	2.5	2.3	..	..	..	2.2
	Average		3.7				2.6				2.2		

TABLE III.—*Table correcting the previous results so as to give measurements from the centre of the dial-plate, the elevated pointer being five feet, and the shadows cast at midday.*

This gives us, in fact, the actual shadows in a sun-dial. We add for Athens 5 . cpt 38° = 6.3; for Rome 5 . cot 42° = 5.5; for Placentia 5; for Poitiers 5 . cot 47° = 4.6.

	January	*February*	*March*	*April*	*May*	*June*
Athens	15.3 to 13.1	13.1 to 11.3	11.3 to 9.6	9.6 to 8.4	8.4 to 7.7	7.7 to 7.6
Average	14.5	12.3	10.5	9.0	8.0	7.6
Rome	16.2 to 13.8	13.8 to 11.3	11.3 to 9.3	9.3 to 8	8.0 to 7.3	7.3 to 7.2
Average	15.0	12.5	10.3	8.6	7.6	7.2
Placentia	17.3 to 14.4	14.4 to 11.5	11.5 to 9.4	9.4 to 7.8	7.8 to 7.1	7.1 to 7.0
Average	14.7	12.9	10.4	8.5	7.4	7.0

We can see at a glance, from the proportion of the shadows in the table, that the shadows are not those of a sun-dial.

TABLE IV.—*Lengths of shadows at the summer solstice for the six hours of the day; with a five-foot style.*

Hours	i	ii	iii	iv	v	vi
According to Palladius	xxii	xii	viii	v	iii	ii
In latitude 42°	22.2	10.1	5.9	3.2	2.4	1.7
In latitude 45°	22.7	10.0	8.6	5.3	2.5	2.0
In latitude 47°	23.8	10.7	6.9	4.0	2.6	2.2

Observing that on account of the irregular run of the clepsydra the hours are most accurately measured in the middle of the run; and that the elevation of the sun by refraction diminishes the shadow as calculated theoretically, which makes a very sensible difference when the sun is on the horizon; we conclude in favor of latitude 45°, but 47° is better than 42°.

TABLE V.—*Showing the shadows for every hour of the civil (actual) day, at the equinox, for three principal latitudes.*

Horae	i	ii	iii	iv	v	vi	
Palladius, results between	25 23	15 14	11 10	8 7	6 5	5 4	pedes
Latitude 42°	25.4	12.5	8.0	5.9	4.8	4.5	
Latitude 45°	26.8	13.2	8.6	6.4	5.3	5.0	
Latitude 47°	27.8	13.7	9.0	6.8	5.7	5.3	

Note 1: *On Exsuperantius.*[1] He was born at Poitiers in the 4th century . . . and was a relative and friend of Rutilius, who speaks in his praise in the first book of his Itinerary. He had applied himself particularly to the study of Jurisprudence, and it is believed that he had composed treatises on that science. One of his brothers, Quintilius or Quintilianus, had retired to the solitude of Bethlehem, where he lived under the direction of Jerome. At his direction the holy doctor wrote to Exsuperantius a letter,[2] which has been preserved, and in which he exhorts him to follow the example of his brother. Exsuperantius, however, would not renounce the advantages which the world seemed to offer him. Nominated to the important office of prefect of the Praetorium among the Gauls, he occupied himself in re-establishing order and police in the *Armorican* provinces; he succeeded in expelling the Goths, and in quieting disturbances occasioned by the levy of new taxes. At last he came to Arles, believing that his presence would suffice to reduce to order the revolted legions; but as soon as he appeared amongst the mutinous soldiers, they surrounded him and stabbed him to death. The death of Exsuperantius happened in 424, under the reign of the weak John, who did not even order search to be made for the assassins.

Note 2: *On Rutilius.*

Tum discessurus, studiis urbique remitto
  Palladium, generis spemque decusque mei,
Facundus juvenis Gallorum nuper ab arvis
  Missus Romani discere jura fori.
Ille meae secum dulcissima vincula curae,
  Filius adjectu, stirpe propinquus habet.
Cujus Aremoricas pater Exsuperantius oras
  Nunc postliminium pacis amare docet.

ITINERARY, I 208

Note 3: *On the French Reaping Machine of the 5th century.* It is, to say the least, somewhat astonishing to find an early account of a reaping machine used in the level parts of Gaul, not very dissimilar from those employed in the great West to-day. "Pars Galliarum planior hoc compendio utitur ad metendum, et praeter hominum labores, unius bovis opera spatium totius messis absumit. Fit itaque vehiculum, quod duabus rotis brevibus fertur. Hujus

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[1] Weiss in Michaud, Biographie Universelle.

[2] It is Ep. CXLV in Migne's Patrologia.

quadrata superficies tabulis munitur, quae forinsecus reclines in summo reddant spatia largiora, ab ejus fronte carpenti brevior est altitudo tabularum. Ibi denticuli plurimi ac rari ad spicarum mensuram constituuntur in ordinem, ad superiorem parte recurvi a tergo vero ejusdem vehiculi duo brevissimi temones figurantur velut amites basternarum. Ibi bos capite in vehiculum verso jugo aptatur et vinculis, mansuetus sane, qui non modum compulsoris excedat. Hic ubi vehiculum per messes coepit impellare, omnis spica in carpentum denticulis comprehensa cumulatur, abruptis ac relictis paleis ; altitudinem vel humilitatem plerumque bubulco moderante qui sequitur ; et ita per paucos itus et reditus brevi horarum spatio tota messis impletur. Hoc campestribus locis vel aequalibus utile est et iis quibus necessaria palea non habetur."

J. RENDEL HARRIS.